Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

Six hundred and eighteenth Meeting.

March 8, 1870. — Adjourned Statute Meeting.

The President in the chair.

The President called the attention of the Academy to the recent decease of Dr. Theodore Strong, of New Brunswick, N. J., of the Associate Fellows.

The President communicated a report from the Council, nominating candidates for Associate and Foreign Honorary membership, and also read nominations of candidates for Resident Fellowship.

A committee was appointed to confer with other learned societies to secure a building for their accommodation with the Academy. The Vice-President, and Messrs. Nathaniel Thayer, William Gray, J. I. Bowditch, and C. W. Eliot, were appointed on this committee.

Six hundred and nineteenth Meeting.

April 12, 1870. — Monthly Meeting.

The President in the chair.

The President called the attention of the Academy to the recent decease of Rev. Dr. Frothingham, of the Resident Fellows.

Mr. C. F. Adams communicated two papers by W. B. Burden, of England, which were referred to Mr. Francis and Mr. Batchelder as a committee to examine them.

Six hundred and twentieth Meeting.

May 10, 1870. — Monthly Meeting.

The President in the chair.

The Corresponding Secretary read letters relative to exchanges.

Dr. Clark made a communication on the medical and physiological action of the chloral hydrate.

Professor Lovering made the following communication: —

"Optical Meteorology has been developed mathematically with greater success than any other department of this complex science. The principal features of a fully developed halo are: 1. The inner circle, concentric with the luminary, and having a radius of about 22°. 2. The outer circle, also concentric with the luminary, and having a radius of about 46°. Both of these circles, called the smaller and larger halos, are tinged with the colors of the spectrum, the blue being the outermost color. 3. The parhelion circle which passes through the luminary and is parallel to the horizon. This circle is white. 4. Upon this circle, and at a distance of 22° or more from the luminary, are two mock suns, the edges towards the sun being reddish and the opposite edges bluish. 5. A sort of tail stretching from these mock suns horizontally, and opposite to the line which connects them with the sun, to the distance of 43° 28′, or more, from the sun. 6. The tangent curve to the inner halo. 7. The tangent curve to the outer halo.

All these features of the halo are satisfactorily explained by refraction and reflection, produced by hexagonal prisms of ice, floating or sinking in the higher region of the atmosphere. These particles may be so situated as to present three independent cases. 1. They may be indiscriminately in all possible positions. 2. The axes of the prisms may be parallel and vertical, the sides of the prisms facing all azimuths. 3. The axes of the prisms may be horizontal, but in all possible azimuths. The *first* case would exist when the particles of ice were newly formed, and had not accumulated so much velocity that the resistance of the air would bring the surface of least resistance to the front. If the three dimensions of the crystal were nearly the same, there would be no surface of least resistance, and the air would exercise no directing influence. The *second* case would arise, as the consequence of increasing velocity and resistance, if the *minimum* section of the prism was parallel to the base. The *third* case would arise, under similar circumstances, if the minimum section was perpendicular to the base. All three cases might coexist at the same moment, because some of the prisms were long and others short, and because some of the prisms had had less time than others to fall, and accumulate velocity and resistance, since their first formation.

Of the various angles formed by the sides and ends of these prisms, some would exceed the limit of transmission, others would be zero and produce no refraction. There would remain, of the available angles, those of 60° made by alternate faces, and those of 90° made by the faces and ends of the prisms. The inner halo is caused by refraction through an angle of 60°, the refracting edges being parallel to the tangents to different parts of the halo. The outer halo is caused by refraction through an angle of 90°, the refracting edges of different prisms being parallel to different tangents. Both halos require that the prisms should be scattered at random, so that a sufficient number would be found in the required positions. The white parhelion circle is produced by reflection from the sides of the prisms when their axes are vertical. These same prisms, acting through the angle of 60°, would produce the mock *suns* whenever they stood in the position of minimum deviation; while others, not in the position of minimum deviation, would produce the colored appendages to the mock suns. These same prisms, acting through the angle of 90°, would cause the tangent curve to the larger halo of 46°. If the luminary were above the horizon, reflection from the upper end of these prisms would produce an uncolored image of the luminary underneath the real luminary; but this image would not be visible unless the observer were elevated to a great height above the surface of the earth. If the luminary were a little below the horizon, reflection from the lower end of these prisms would produce a similar image above the luminary, and above the horizon, which would be visible; and hence the luminary might appear to have risen again after setting. When the axes of the prisms are horizontal, refraction by the angle of 60° would cause the tangent curve to the inner halo of 22°. If large numbers of prisms were floating contemporaneously in all three positions, all these phenomena might coexist; otherwise, only a portion of these various features would be displayed. It is evident, therefore, that both halos might be wanting, and yet one or both of the curves which are tangent to them might appear. If the tangent curve to the larger halo of 46° is seen, generally the mock *suns* and the *parhelion* circle are also seen, even in the absence of the halo itself. In other words, all which vertical prisms are capable of producing would generally, though not necessarily, be seen at the same time.

These general features are somewhat changed by the altitude of the sun, or other luminary, above the horizon. When the sun is in the horizon, the parhelia are at the same distance from it as the inner halo, and rest upon it. As the sun rises they go outside of the halo, and become impossible when the altitude of the sun exceeds 60° 45′. The lengths of the tails affixed to the mock suns increase as the sun rises, until the limiting angle of transmission is reached. There is an inferior as well as a superior tangent arc to the halo of 22°. Their figures are complex, and they join in a single curve, circumscribing the halo itself, when the altitude of the sun exceeds 29° 15′. The inferior arc is rarely visible, unless the sun is more than 22° high. The halo of 46° is less bright than that of 22°, because it is larger and broader; and more light is reflected by the prisms under the larger incidences. The tangent curve to this halo is a circular arc having the zenith for its centre. It cannot be formed if the sun's altitude exceed 32° 12′. The semi-amplitude increases from 57° 48′ to 90°. But when it is 90°, its height is also 90° and its radius is reduced to zero. The maximum brightness is in the middle of the whole arc. This arc actually touches the halo of 46° only when the altitude of the sun is 22° 8′. It sensibly touches between the altitudes of 15° and 28°. If the sun were in the horizon, the tangent arc would be 12° 4′ above the summit of the halo. If the sun were 30° high, the tangent arc would be 3° 39′ above the halo. The altitude of 22° 8′ is most favorable, because, in this case, the middle of the arc is formed by rays which have suffered a *minimum* deviation. A tangent arc to the lowermost point of this halo is not impossible, but rare. In this event, the light must enter a vertical face and emerge at the base. The limits of altitude are complementary to those which the superior tangent requires; that is, the sun's altitude must be between 57° 48′ and 90°, the arc actually touching the halo at the special altitude of 67° 52′. If the axes of the prisms are shifted from a vertical to a horizontal position, the inferior and superior tangent arcs are changed to what are called *infra-lateral* and *supra-lateral.*

I have taken renewed interest in this theory of halos, which has been admirably developed by Bravais,* on account of the halo seen at Cambridge, January 6, 1870. This halo was seen about two o'clock, when the altitude of the sun was not far from 25°. The principal feature of the phenomenon, on that occasion, was the tangent curve to the halo of 46°, though the halo itself was not visible. At Waltham, the mock suns were seen, but not the tangent curve. The tangent curve seemed to be a *complete* circle, and the colors were very vivid, the red being the outermost color, or nearest to the sun. I have stated that, theoretically, the *maximum* amplitude of this curve is 180°, and, if the sun had an altitude of 25°, the amplitude would be only about 138°. The history of halos furnishes but few examples of this extraordinary occurrence, — a complete circumzenithal circle. On the 24th of January, 1838, Lambert* saw at Wetzler a circle, nearly complete, centred about the zenith, with vivid prismatic colors. On the 11th of July, 1749, Anderon† witnessed at Norwich, about five o'clock, P. M., when the sun was nearly 25° high, a *white* circle around the zenith. Bravais resorts to two expedients for explaining the enlargement of the circumzenithal arc into a complete circle, in a few rare cases. In the first place, the light may strike the vertical side of the prism too obliquely to be transmitted, so that, after being once or twice reflected upon other vertical sides, it may emerge from sides opposite to the usual ones. In the second place, each point of the arc, originally produced, causes a parhelion *circle*, all of which are superimposed upon the arc itself, as far as it extends. This last operation, however, would produce light without any discoloration. In the halo seen at Cambridge, the centre of the circle was decidedly south of the zenith. This fact requires us to suppose that the parallel axes of the prisms were not exactly vertical. A current in the atmosphere might change the direction of the descending particles of ice, but could the lateral motion, *with* the air, and not *in* it, develop any new resistance which would direct their axes away from the zenith?

---

* Journ. de l'École Polytechnique. Cahier 31. Tome xviii.

I will now exhibit an experiment with an equilateral triangular prism of glass, and also a hollow one filled with water. The axis is vertical, about which it is made to revolve rapidly by clock-work. With a single prism and sunlight, or any bright and circular artificial light, all those features of the halo may be artificially produced which have been referred to the action of many prisms of ice, with vertical axes: the single prism, in its motion, assuming, in rapid succession, all the possible positions of these many prisms in the atmosphere. The halos themselves can be produced artificially, either by a conical prism, or by artificial crystals formed upon a plate of glass, as shown by Brewster ‡ and others. §

The sun and moon are sometimes encircled by what are called coronæ. A corona may be distinguished from a halo in many ways. 1. It is much smaller even than the smallest of the two halos. 2. It is not rigidly bound to almost invariable dimensions, as the halo is. 3. When it is bright enough for the colors to be distinguished, the red is outside and the blue inside. 4. This arrangement of the colors, as well as the dimension of the circle, indicate that a corona is not produced by refraction or reflection in crystals of ice, but by interference. The following experiments which I shall now exhibit to the members of the Academy, will illustrate this subject. When light is sent through the intervals between straight and parallel lines, which have been nicely ruled upon glass, a series of colored fringes, parallel to the lines, results from the interference between rays which pass through different openings. If the glass were ruled with concentric circular lines, close together, these colored bands would become circular, and surround the source of light. By a rapid rotation of the ruled lines in their own plane, subjective rings result from the parallel fringes. In order to produce the required rotation without a material axis, which would intercept the rays of light from the eye of the observer, a platform is turned rapidly by clock-work. The border of this platform is covered with cloth. The circular frame in which the graduated glass is set rests upon this cloth, with its plane at right angles to the platform, and is rotated by friction. Friction-rollers at the sides and top hold it in its place, in the absence of any material axis of rotation. If concentric black circles are accurately drawn upon paper, and then photographed upon glass, on a greatly reduced scale, the photographed plate might be substituted for that on which circular lines had been scratched. Again, if a plate of glass is covered with india-ink, and then concentric circles are scratched upon the black surface, leaving the intermediate black rings, the same optical experiment can be performed. All three of these methods have been tried, but the finest and neatest circles were obtained by the last method; and the experimental result is very beautiful, especially if the ruled glass is placed immediately in front of the object-glass of an opera-glass.

---

* Pogg. Ann. Physik und Chemie, xlvi. p. 660.

† Phil. Trans. xlvi. p. 203.

‡ A Treatise on Optics. Amer. edit. 1835, pp. 232, 233.

§ Amer. Journ. xvi. 398.

Although artificial coronæ of great beauty can be produced in these ways, it is obvious that the coronæ of nature must have a much simpler origin. And theory shows, that if lycopodium powder, the particles of which are small and spherical, and of uniform size, is sprinkled upon glass, a luminous spot, seen through the glass, will be surrounded with several coronæ, which, if less bright than those produced by the concentric rulings, on that very account have a greater resemblance to those known in Meteorology. It appears that, in this indiscriminate sprinkling, myriads of minute openings are left everywhere on the plate, enough being found in the required places for producing the colored rings. Of these the light takes advantage for producing a symmetrical effect, just as in the formation of the rainbow it selects those individual drops of moisture which serve its purpose, while the remainder of the drops are inoperative. A piece of very delicately ground glass accomplishes the same result. In the atmosphere, the place of the lycopodium powder is filled by the particles of moisture existing in the vesicular state; and the smaller these particles the larger will be the diameters of the coronæ which they produce. In this way these particles are proved to vary between the .001 and the .002 of one inch in diameter.*

Coronæ indicate the presence of the *cumulus* cloud; but halos imply the *cirrus* cloud, floating at great heights, and within the region of perpetual congelation. For halos are seen even in the summer and in the tropics. By revealing the incipient gathering of the cirrus cloud, they may foretell the approach of a storm.

Six hundred and twenty-first Meeting.

May 24, 1870. — ANNUAL MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary communicated letters relative to exchanges, and read a report from the Council proposing nominations for Foreign Honorary and Associate Membership.

The Treasurer presented his report for the past year, and read a synopsis of it. The report was received, to be entered on the records.

Professor Lovering reported from the Committee of Publication its expenditures for the past two years. The report was accepted.

Professor F. H. Storer reported for the Committee on the Library on the condition of the Library.

Professor Winlock reported, from the Rumford Committee, the completion of Vol. I. of Count Rumford's works, and recommendations of this committee for appropriations from the Rumford Fund. This report was accepted, and in accordance with its recommendations the following votes were passed: —

---

* Kaemtz's Complete Course of Meteorology, p. 111.